Research on nitrate removal from simulated groundwater by iron nanoparticle-loaded graphene

Yanhua Wang a,b,*, Shengke Yang b,*, Bin Li b

a School of Geography and Tourism, Shaanxi Normal University, Xi’an, China, Tel. +86 13991828224; email: yhwang930@foxmail.com
b Key Laboratory of Subsurface Hydrology and Ecology in Arid Areas, School of Environmental Science and Engineering, Chang’an University, Xi’an, China, Tel. +86 15991655210; email: ysk110@126.com (S. Yang), Tel. +86 18049231762; email: 395820930@qq.com (B. Li)

Received 30 August 2016; Accepted 11 January 2018

ABSTRACT

Nitrate is one of the most frequent pollutants of groundwater, and in some areas, nitrate pollution is becoming a serious problem. While graphene has been widely used in the processing of heavy metal ions in aqueous solution, its role in nitrate removal remains largely unexplored. In this study, we loaded micro-sized graphene with nanoscale iron particles (G-Fe) by liquid-phase reduction. The characteristics of nitrate reduction by nanoscale zero-valent iron and G-Fe composites were determined under different conditions using static experiments, to reveal the reaction mechanism in removing nitrates. Under the same reaction conditions and dosing level, G-Fe achieved higher reaction rate and removal efficiency of nitrates, with a lower production rate of ammonia. Results show that the optimal load ratio of graphene with nanoscale iron is 5:1. Lower initial pH improves nitrate removal efficiency (NRE) to varying degrees and 100% removal is obtained at pH 2.15. Dissolved oxygen has no effect on NRE. The effect of coexisting anions on NRE descends as follows: PO_{4}^{3–}, SO_{4}^{2–}, and Cl–.

Kinetic studies show that the reaction order between G-Fe and nitrate is about 0.45, indicating that the reaction involves complex redox reactions and adsorption/desorption processes, other than a simple first-order reaction. This study demonstrates the effectiveness of G-Fe composites in nitrate removal and establishes an advanced technology for groundwater remediation.

Keywords: Micro-sized graphene; Nanoscale zero-valent iron; Groundwater; Nitrate removal; Kinetic reaction mechanism